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Alleviating Software Piracy: The Role of Online Renting

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ABSTRACT

Online rental of software is emerging as a new way of dissemination for several major software firms. Compared to outright selling, the renting scheme delivers the software as a service instead of a physical good. Hence, users cannot privately make copies for resale in the market. We investigate the impact of the renting mechanism on software piracy and pricing in a two-period model whereby a piracy market is present in the second period. We develop and compare models with or without renting. Our analyses show that renting reduces social welfare but helps to increase a vendor's profit under certain conditions.

INTRODUCTION

Online rental of software is increasingly being practiced by some major software companies. For instance, since 1996, Microsoft has launched the electronic distribution framework, which allows the consumers to pay a monthly fee for accessing the software over Internet. Recently, Microsoft even rented its office suite online, allowing people to use Microsoft Word, Excel and PowerPoint on a lease agreement. Several technologies such as Citrix and Internet2, are emerging to enable remote delivery of software to end users in a scalable and reliable fashion.

A distinguishing feature about the online rental mechanism is that the software is installed in the servers of vendor instead of the end-user's desktop. Vendors can use monitoring software to ensure that there is no 'leakage' outside of the lease agreement. Compared to outright selling, vendors can alleviate the problem of end-user piracy (private copying) through this mechanism. Piracy has been a perennial problem since the advent of the software industry. Particularly, the emergence of Internet makes private copying even easier and cheaper. Business Software Alliance reported $12 billion losses globally from piracy (BSA, 1999). Governments of many countries have enacted laws to protect publishers and authors by enforcing a penalty on infringement. For example, the US congress passed the No Electronic Theft Act in 1997 and the Digital Millennium Copyright Act in 1998.

We are interested in the impact of renting on software piracy. In this paper, we treat software as a durable product that lasts for two periods, and consider private copying in the second period only. We compare the vendor's pricing strategy and profit with or without renting option, and analyze the consequences for social welfare under each option.

We found that when government enforces a penalty on piracy, the producer is better off by offering an inferior version in the renting option, and some consumers will shift from the copying to the renting market segment. However, social welfare will decrease instead. We examine the optimal government policy to tackle software piracy.

LITERATURE REVIEW

Economics of copying has long been studied by academics. Some papers examined the impact of piracy on the producer's sales and profit. Two main effects are identified (Varian, 2000). First, piracy will directly reduce demand of legitimate products. Second, originals are more valuable when copying is possible. Liebowitz (1985) argued that the relative cost of producing originals and copies is a key determinant in the change of profit. Particularly, profit will decrease when private copying is costly. These results were obtained under the assumption that the producer can price discriminate to capture the values of the copies made from each original (indirect appropriability). One group of papers studies the case when network externality is present. Copying might encourage legitimate sales when network externality is strong (Conner, 1991) or diffusion of copying is faster (Muller, 1995). A producer might deliberately facilitate copying to expand the installed base when there is competition (Shy, 1999, Takeyama, 1994)

Some papers examine producers' response to piracy, such as the decision on the level of quality in production (Waldman, 1984), the extent of protection (Conner, 1991), and the optimal level of pricing (Fernando, 1986).

Other papers focus on the impact of piracy on social welfare and the optimal government policy. Generally, this impact is complex. Producers are believed to under-produce in the presence of copying. Increasing copyright protection might encourage producers to raise production but might induce greater social welfare loss due to underutilization (Waldman, 1984). Besen and Kirby (1989) summarized the impact on producer and consumer welfare under different assumptions: (1) the extent to which the producer can appropriate the consumer surplus; and (2) the substitutability of copies compared to the original.

The recent emergence of online rental of software has also attracted some academic attention. Choudhary, Tomak and Chaturvedi (1998) discussed the benefits of renting in the presence of network externality. Gurnari and Karlapalem (2001) studied the actual usage behavior of consumers, and concluded that renting could expand the market size by tailoring the product to the needs of a particular client. However, most of the literature on online rental of software seems to neglect the existence of a piracy market. Additionally, little attention is being paid to understanding the link between private copying and the distribution mechanism.

This paper seeks to bridge the gap between the copying and the online rental literature by examining the effects of renting on software piracy and pricing. We employ a two-period model, which has been previously used in studying traditional durable goods such as automobile and household appliances (Bulow, 1982, Purohit, 1999). We assume that short-term rental lasts for only one period, and copying emerges only in the second period (since pirated product generally comes after the original market). We analyze the resulting market segmentation and the corresponding pricing strategy for a monopolist producer.

We explore the following research questions: (i) Does renting help counter software piracy, and under what conditions? (ii) What is the optimal pricing strategy for the vendor when both selling and renting are used? (iii) How does renting affect social welfare?

THE MODEL

We consider a software product market under a monopolist software vendor. It is a two period model: In the first period, the producer both sells and rents, and rental only lasts for one period. In the second period, producer sells and faces a copying market.

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We assume there is Bertrand competition in the piracy market, which drives the price to the marginal cost. Following this typical assumption on information goods, marginal costs are zero in our model. (see Bakos et al.1998)

Following the market segmentation in some previous studies (Conner, 1991), we assume that there is a continuum of consumers indexed by the reservation price $h \in [0,1]$. Depending on the prices, consumers make the optimal decisions according to their preference. In the first period, consumer decides whether to buy or rent or just stay out of the market. Consumers who buy in the first period do not need to do anything in the second period, while those who rent or stay out of the market would choose to buy the legal product, or to buy pirated copy or do nothing at all. If consumers choose to buy and use pirated copies, then they may be caught and penalized later.

We define Ω_{b1} to be the software products sold to the consumers in the first period, Ω_r to be the products leased, Ω_{b2} to be the legal product sold in the second period, and Ω_c to be the pirated copies. Let p_{b1}, p_r, p_{b2} be the price for $\Omega_{b1}, \Omega_r, \Omega_{b2}$, respectively. Note that the price for Ω_c is zero.

Let (x_1, x_2) be a consumer's choice, where $x_1 \in \{b, r, 0\}$ represents three choices in the first period – buying, renting, doing nothing, respectively; and $x_2 \in \{b, r, 0\}$ represents three choices in period two –buying Ω_{b2}, buying Ω_c, doing nothing, respectively.

To examine the software vendor's incentives to provide rental option to control software piracy, we compare two cases for the vendor: one with the rental option and the other without the rental option. For each case, we first examine the consumer's choice and the corresponding surplus functions and we would then derive the demand function and the monopolist's profit.

Without Rental Option

In this case, the software provider only sells Ω_{b1} in the first period. Consumer decides whether to buy it or not. Non-buying consumers might buy Ω_{b2} or Ω_c or do nothing in the second period. Space for consumer's choices can be represented by {(b, 0) (0, b) (0, c) (0, 0)}. For a consumer with the choice (b,0), his surplus would be

$$V_{(b,0)} = 2h - p_{b1} \quad (1)$$

Here, we assume that the surplus derived by consuming the product for one period is h, hence for two periods it is $2h$.

Secondly, for consumer choosing (0,b), who first waits and then buys the legal product in the second period, his surplus would be

$$V_{(0,b)} = \beta(h - p_{b2}) \quad (2)$$

where $\beta \in (0,1)$ is a discount factor.

Third, if the consumer buys the pirated copy, then his surplus would be

$$V_{(0,c)} = \beta(dh - f) \quad (3)$$

where $d \in (0,1)$ measures the degree of substitutability between the pirated copies and the original. The pirated copy might not be perfect because it might contain inconsistent, corrupt files or unresolved bugs. f is the expected value of fine, which is the probability for a pirated copy user to be caught multiplied by the fine set by government. We assume consumers are risk-neutral.

Finally, if consumer does nothing at all in both of the period, his surplus would be zero.

Given the surplus function for each choice, consumers would be self-selected into different groups according to their reservation price for the product. Consumers are assumed to have unit demand. Denote the quantity for each group with Q. We can derive $Q_{(b,0)}$ by finding the marginal consumer who is indifferent between choosing (b,0) and (0,b). Let h_1 be the reservation price for this marginal consumer. It is also the lowest reservation price among consumers who choose (b,0). Since $V_{(b,0)} - V_{(0,b)}$ is increasing in h ($2 \geq \beta \geq \beta d$), all consumers with $h > h_1$ would choose (b,0) over (0,b). Therefore, $Q_{(b,0)}$ would be $1 - h_1$. Similarly we can derive other demand functions for (0,b), (0,c).

By solving $V_{(b,0)} = V_{(0,b)}$, $V_{(0,b)} = V_{(0,c)}$, $V_{(0,c)} = 0$ for h, we can get

$$h_1 = \frac{p_{b1} - \beta p_{b2}}{2 - \beta}$$

$$h_2 = \frac{p_{b2} - f}{1 - d}$$

$$h_3 = \frac{f}{d}$$

We have the following constraints $1 \geq h_1 \geq h_2 \geq h_3 \geq 0$.

Then, the demand function can be derived as

$$Q_{(b,0)}(p_{b1}, p_{b2}) = 1 - h_1$$

$$Q_{(0,b)}(p_{b1}, p_{b2}) = h_1 - h_2$$

$$Q_{(0,c)}(p_{b1}, p_{b2}) = h_2 - h_3$$

The monopolist software vendor will maximize the profit by setting the discriminated prices for both of the period, that is,

$$\underset{(p_{b1}, p_{b2})}{Max} \pi = p_{b1} Q_{(b,0)} + \beta p_{b2} Q_{(0,b)} \quad \text{subject to} \quad 1 \geq h_1 \geq h_2 \geq h_3 \geq 0.$$

By finding the first order condition with respect to p_{b1}, p_{b2}, we get

$$p_{b1}^* = \frac{2 + \beta(f - d)}{2} \quad (4)$$

$$p_{b2}^* = \frac{1-d+f}{2} \quad (5)$$

The optimal demand from each group would be

$$Q_{(b,0)}^* = \frac{1}{2} \quad (6)$$

$$Q_{(0,b)}^* = \frac{f}{2(1-d)} \quad (7)$$

$$Q_{(0,c)}^* = \frac{1}{2} - \frac{f(2-d)}{2d(1-d)} \quad (8)$$

And

$$\pi^* = \frac{1}{2} + \frac{\beta}{4}(2f + \frac{f^2}{1-d} - d) \quad (9)$$

It is showed that when $f = 0$, $Q_{(0,b)}^* = 0$, so it is always optimal to sell only in the first period. Here, we have proposition 1.

Proposition 1: Government's penalty enables the producer to version his product for increased profitability.

Versioning leads to two results: on one hand, its lower price helps to expand the market by attracting some people from buying pirated copy to buying legal product; on the other hand, it also cannibalizes sales of the superior product in the first period. It is showed that, when $f = 0$, the loss from cannibalization cannot be covered by the benefits gained from the expanded market. Therefore, product versioning is not optimal when $f = 0$.

When $f > 0$, the monopolist can differentiate the products more effectively. Particularly, we have $\frac{\partial Q_{(0,b)}^*}{\partial f} > 0$ and $\frac{\partial \pi^*}{\partial f} > 0$.

When $f > \frac{d(1-d)}{2-d}$, $Q_{(0,c)}^* = 0$, and pirated copies will be completely driven out of the market.

With Rental Option

Next, we discuss the case with rental option. We assume that rental exists only in the first period (see Choudhary et al.1998, Bulow et al.1982). Rental is generally short-term in nature: hence it is not considered in the second period. For consumers, they can either buy or rent or do nothing in the first period. Some people choose renting over buying since it is more affordable ($p_{b1} > p_r$) or they may just need the software for short-term usage. If he rents or does nothing, he might consider buying legal or pirated copy in the second period.

The surplus obtained from the rental product is

$$V_{(r,0)} = kh - p_r \quad (10)$$

where $k \in (0,1)$ captures utility difference between the purchased products and the rental products. The rental products might cause some inconvenience for users.

When the rental option is introduced, space for consumer's choices would be {(b, 0) (r, b) (r, c) (0, b) (r, 0) (0, c) (0, 0)}. The versions of products for these seven groups are sorted from the highest to the lowest given the condition that $k + \beta d > \beta > k > \beta d > 0$, which implies that consumers get more benefits by buying than renting, and the rental products provide more benefits than the pirated copies.

Though there are seven possible groups, they actually cannot exist simultaneously. (Please see the proof in Appendix.) We identified three cases. For each case, we solve for the optimal pricing strategy.

Case 1 $0 < f \le \frac{d(k-\beta d)}{2k-\beta d}$

Buy at the beginning $V_{(b,0)} = 2h - p_{b1}$ (11)

Rent then buy $V_{(r,b)} = kh - p_r + \beta(h - p_{b2})$ (12)

Rent and nothing $V_{(r,0)} = kh - p_r$ (13)

Copy $V_{(0,c)} = \beta(dh - f)$ (14)

By solving $V_{(b,0)} = V_{(r,b)}$, $V_{(r,b)} = V_{(r,0)}$, $V_{(r,0)} = V_{(0,c)}$, $V_{(0,c)} = 0$ for h_4, h_5, h_6, h_7, we get

$$h_4 = \frac{p_{b1} - p_r - \beta p_{b2}}{2 - k - \beta}$$

$$h_5 = p_{b2}$$

$$h_6 = \frac{p_r - \beta f}{k - \beta d}$$

$$h_7 = \frac{f}{d}$$

Then, the demand function can be derived as

$$Q_{(b,0)}(p_{b1}, p_r, p_{b2}) = 1 - h_4$$

$$Q_{(r,b)}(p_{b1}, p_r, p_{b2}) = h_4 - h_5$$

$$Q_{(r,0)}(p_{b1}, p_r, p_{b2}) = h_5 - h_6$$

$$Q_{(0,c)}(p_{b1}, p_r, p_{b2}) = h_6 - h_7$$

The monopolist software vendor will maximize the profit by setting the discriminated prices for both of the periods, i.e. $\underset{(p_{b1}, p_r, p_{b2})}{Max\pi} = p_{b1}Q_{(b,0)} + p_r(Q_{(r,b)} + Q_{(r,0)}) + \beta p_{b2}Q_{(r,b)}$

subject to $1 \ge h_4 \ge h_5 \ge h_6 \ge h_7 \ge 0$.

Optimal prices are

$$p_{b1}^* = \frac{2+\beta(f-d)}{2} \quad (15)$$

$$p_r^* = \frac{k+\beta(f-d)}{2} \quad (16)$$

$$p_{b2}^* = \frac{1}{2} \quad (17)$$

then optimal quantities are

$$Q_{(b,0)}^* = \frac{1}{2} \quad (18)$$

$$Q_{(r,b)}^* = 0 \quad (19)$$

$$Q_{(r,0)}^* = \frac{\beta f}{2(k-\beta d)} \quad (20)$$

$$Q_{(0,c)}^* = \frac{1}{2} - \frac{\beta f}{2(k-\beta d)} - \frac{f}{d} \quad (21)$$

and

$$\pi^* = \frac{1}{2} + \frac{\beta}{4}(2f + \frac{\beta f^2}{k-\beta d} - d) \quad (22)$$

The optimal strategy for the monopolist is to sell and rent only in the first period and not to sell in the second period ($Q_{(r,b)}^* = 0$).

Particularly, the constraints $1 \geq h_4 \geq h_5 \geq h_6 \geq h_7 \geq 0$ should not be violated. By submitting $(p_{b1}^*, p_r^*, p_{b2}^*)$, we have the condition $0 < f \leq \frac{d(k-\beta d)}{2k-\beta d}$.

Similarly, we can solve for other two cases.

Case 2 $\frac{d(k-\beta d)}{2k-\beta d} < f \leq \frac{d(1-d)}{2-d}$

The optimal solution is

$$p_{b1}^* = \frac{2+\beta(f-d)}{2} \quad (23)$$

$$p_r^* = \frac{k}{2} \quad (24)$$

$$p_{b2}^* = \frac{1-d+f}{2} \quad (25)$$

the optimal quantity for each segment is

$$Q_{(b,0)}^* = \frac{1}{2} \quad (26)$$

$$Q_{(r,b)}^* = 0 \quad (27)$$

$$Q_{(0,b)}^* = \frac{f}{2(1-d)} \quad (28)$$

$$Q_{(0,c)}^* = \frac{1}{2} - \frac{f(2-d)}{2d(1-d)} \quad (29)$$

and $\pi^* = \frac{1}{2} + \frac{\beta}{4}(2f + \frac{f^2}{1-d} - d)$ (30)

Please note that $Q_{(r,b)}^* = 0$. That means no renting option is best for the monopolist.

Case3 $f = 0$

The optimal solution is

$$p_{b1}^* = \frac{2+\beta(f-d)}{2} \quad (31)$$

$$p_r^* = \frac{k}{2} \quad (32)$$

$$p_{b2}^* = \frac{1-d+f}{2} \quad (33)$$

the optimal quantity for each segment would be

$$Q_{(b,0)}^* = \frac{1}{2} \quad (34)$$

$$Q_{(r,b)}^* = 0 \quad (35)$$

$$Q_{(r,c)}^* = 0 \quad (36)$$

$$Q_{(0,c)}^* = \frac{1}{2} \quad (37)$$

and $\pi^* = \frac{2-\beta d}{4}$ (38)

Again, when the government exacts no penalty, the optimal strategy for the monopolist is to provide only first period sales and without renting option.

Comparison

First, we investigate the impact of offering renting from the standpoint of the software vendor. We compare the profit of the monopolist with or without renting option. We denote profit with renting with π^{*rent}, and profit without renting with $\pi^{*norent}$.

For case 1, $\pi^{*rent} - \pi^{*norent} = \frac{\beta f^2(\beta-k)}{4(k-\beta d)(1-d)} > 0$.

And, in case 2 and case 3, profit does not change since it is optimal not to offer rental products.

Proposition 2: The software vendor can increase the profit by offering the rental option only if the government penalty satisfies $0 < f \le \frac{d(k-\beta d)}{2k-\beta d}$.

When $f \ge \frac{d(k-\beta d)}{2k-\beta d}$, the penalty is high enough to drive out copying; therefore no renting is needed. When $f = 0$, no renting will change the market share of pirated copies. When f is in the intermediate range, by introducing a lower version ($k \le \beta \le 1$) product — the rental product, the monopolist expands its market size substantially, attracting not only the consumers who originally buy at the second period but also some consumers who would buy the pirated copy. Particularly, revenues from renting exceed the losses from selling in the second period, that $p_r^{*rent} Q_{(r,0)}^{*rent} - \beta p_{b2}^{*norent} Q_{(0,b)}^{*norent} = \frac{\beta f^2(\beta - k)}{4(k-\beta d)(1-d)} > 0$.

In summary, software provider increases the profit by covering a bigger market using a relatively lower version of the product.

Proposition 3: When $0 < f \le \frac{d(k-\beta d)}{2k-\beta d}$, *Renting helps more when the penalty is higher and the pirated copies approximating closer to the original, that is,* $\frac{\partial(\pi^{*rent} - \pi^{*norent})}{\partial d} > 0$ *and* $\frac{\partial(\pi^{*rent} - \pi^{*norent})}{\partial f} > 0$.

The intuition behind is that, when quality of pirated copies is good, the vendor has more incentives to offer the renting option to compete against them. Since the higher penalty allows the vendor to price discriminate more effectively, the advantage brought by renting becomes obvious.

Proposition 4: When $0 \le f \le \frac{d(1-d)}{2-d}$, *the higher the substitutability of pirated copies or rental products, the lower the profit of monopolist (*$\frac{\partial \pi^{*rent}}{\partial d} < 0$, $\frac{\partial \pi^{*rent}}{\partial k} < 0$*); and the higher the penalty by government, the higher the profit of monopolist (*$\frac{\partial \pi^{*rent}}{\partial f} > 0$*).*

The first two terms are obvious. When the substitutability of the pirated copies is higher, there is more competition from the copying market, which reduces the sales of legitimate product more. As the government penalty increases the cost of pirated copies, making them less attractive, the provider's loss due to piracy is greatly reduced.

The last term means that the version of rental products should not be too high since it will cannibalize the sales in the first period. Suppose the condition $k > \beta d$ holds, the optimal version of rental products should be close to the version of the pirated copies.

WELFARE ANALYSIS

Next, we investigate the impact of renting on social welfare. Following the utilitarian approach by Waldman (1991), social welfare is the sum of the surplus of consumers, the profit of vendor, and the fine collected by government. We denote the welfare without renting and case 1 with renting with $W^{*norent}$, W^{*rent}, respectively.

$$W^{*norent} = \frac{3}{4} + \frac{\beta}{8}\left(2f + d - \frac{f^2(4-3d)}{(1-d)d}\right) \quad (39)$$

$$W^{*rent} = \frac{3}{4} + \frac{\beta}{8}\left(2f + d - \frac{f^2(4k-3\beta d)}{(k-\beta d)d}\right) \quad (40)$$

Proposition 5: Introduction of renting will result in the loss of social welfare. That is, $W^{*rent} - W^{*norent} = -\frac{\beta f^2(\beta - k)}{8(1-d)(k-\beta d)} < 0$.

This is due to the underutilization of the lower version of the rental product. When the rental option is introduced, buying consumers in period two would switch to renting. Since this rental product has a lower version, the consumer surplus is reduced.

Proposition 6: The higher the substitutability of pirated copies or rental products, the higher the social welfare. ($\frac{\partial W^{*rent}}{\partial d} > 0$, $\frac{\partial W^{*rent}}{\partial k} > 0$*)*

Since the higher version of products provides higher utility for consumers, both increasing the version of pirated copies and the rental products would benefit the consumers. Therefore, for societal sake, software vendors should be encouraged to produce a higher version of the product, say, by improving the service in renting. However, we know from the previous result (proposition 4) that the vendor is worse off in this way.

Proposition 7: To maximize the social welfare, the optimal penalty by government is $f^* = 0$.

From proposition 5, we know that renting always results in a social loss. Therefore, renting should not be offered for the benefit of society. Since the penalty just prevents people from using the pirated copy, it is optimal not to set any penalty.

For the case with renting option, we found that the second optimal solution $f^* = \frac{(k-\beta d)d}{4k-3\beta d}$.

It shows that the penalty should neither be too high nor too low. Government can strike a balance between public benefit and the financial incentives of vendor.

FUTURE RESEARCH EXTENSIONS

The main focus of this paper is to show that renting is a viable strategy in countering the threat of piracy. This is illustrated by increased profits when the vendor has a renting option. We show that, with the introduction of renting, some consumers switch from copying to renting, and the software vendor is better off renting. However, introduction of renting leads to the loss of social welfare. We show the necessary optimal government policy to strike a balance between the vendor and the society.

Our model could be further extended. First, we would assess the difference in outcomes once we take network effects into account. Network externality means that the greater the number of users, the higher the value of the product. Both renting and copying would expand market size, which would lead to network externality. Second, we would consider the case when there is competition in the market.

APPENDIX

Proof of Market Segmentation

Proof for case 1: when (r,0) exists, (0,b) will be dominated, and only one of the two groups (r,c), (0,c) can exist.

(1) Since (r, 0) exist, there should be such h_0 that $V_{(r,0)}(h_0) > 0$ and $V_{(r,0)}(h_0) > V_{(0,b)}(h_0)$, which derive $\frac{p_r}{k} \le \frac{\beta p_{b2} - p_r}{\beta - k} \Rightarrow p_r \le p_{b2} k$. Then, for any $h < \frac{p_r}{k} < p_{b2}$, there is $V_{(0,b)} < 0$, and for $h \ge \frac{p_r}{k}$, there is $V_{(r,b)} > V_{(0,b)}$, so that (0, b) cannot be chosen.

(2) If both (r, c) and (0,c) exist, for people choose copying, there should be such h_0 that $V_{(0.c)}(h_0) > 0$, $V_{(0,c)}(h_0) > V_{(r,0)}(h_0)$, which derive $\frac{f}{d} \le \frac{p_r - \beta f}{k - \beta d} \Rightarrow \frac{f}{d} \le \frac{p_r}{k}$. However, for any $h < \frac{p_r}{k}$, there is $V_{(0,r)} < 0$, and for $h \ge \frac{p_r}{k} \ge \frac{f}{d}$, there is $V_{(r,c)} > V_{(r,0)}$, so that (r, 0) would not be chosen, which contradict with the assumption. <Q.E.D>

Similarly, we can prove the market segmentation for case 2 and 3.

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